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Analysis of cross-correlations in electroencephalogram signals as an approach to proactive diagnosis of schizophrenia

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ABSTRACT

We apply flicker-noise spectroscopy (FNS), a time series analysis method operating on structure functions and power spectrum estimates, to study the clinical electroencephalogram (EEG) signals recorded in children/adolescents (11 to 14 years of age) with diagnosed schizophrenia-spectrum symptoms at the National Center for Psychiatric Health (NCPH) of the Russian Academy of Medical Sciences. The EEG signals for these subjects were compared with the signals for a control sample of chronically depressed children/adolescents. The purpose of the study is to look for diagnostic signs of subjects' susceptibility to schizophrenia in the FNS parameters for specific electrodes and cross-correlations between the signals simultaneously measured at different points on the scalp. Our analysis of EEG signals from scalp-mounted electrodes at locations F_3 and F_4, which are symmetrically positioned in the left and right frontal areas of cerebral cortex, respectively, demonstrates an essential role of frequency–phase synchronization, a phenomenon representing specific correlations between the characteristic frequencies and phases of excitations in the brain. We introduce quantitative measures of frequency–phase synchronization and systematize the values of FNS parameters for the EEG data. The comparison of our results with the medical diagnoses for 84 subjects performed at NCPH makes it possible to group the EEG signals into 4 categories corresponding to different risk levels of subjects' susceptibility to schizophrenia. We suggest that the introduced quantitative characteristics and classification of cross-correlations may be used for the diagnosis of schizophrenia at the early stages of its development.

1. Introduction

The objective diagnosis of psychiatric disorders, such as schizophrenia, at the early stages of their development is complicated by the lack of reliable instrumental methods able to adequately describe these disorders at their onset [1–4]. For example, the methods of electro- and magnetoencephalography are rarely used for the diagnosis of psychiatric disorders, though there are experimental studies suggesting a high potential of these methods [5–7]. This implies that clinical electroencephalogram (EEG) studies are of high concern for advancing the state of the art in the analysis, diagnosis, and prognosis of these disorders.

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